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12-22-95

CONCEPTUAL MODEL FOR

DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

FOR THE NORTH BRONSON INDUSTRIAL AREA

SUPERFUND SITE

December 22, 1995

Prepared for:

THE MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY (MDEQ)
and
U.S. ENVIRONMENTAL PROTECTION AGENCY

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1.0 INTRODUCTION

At the request of the Michigan Department of Environmental Quality (MDEQ), Environmental Standards, Inc. ("Environmental Standards") has developed a conceptual model outlining the methodologies to be utilized in the development of Remedial Action Objectives (RAOs) for the North Bronson Industrial Area Superfund site ("North Bronson site") in Bronson, Michigan. Specifically, Environmental Standards proposes to develop site-specific RAOs that are protective to human health at 1×10^{-5} cancer risk, or a hazard quotient of 1 for noncarcinogens. The purpose of this report is to provide the MDEQ and the U.S. Environmental Protection Agency (U.S. EPA) with detailed information on the methodologies, modeling techniques, intake algorithms, and exposure assumptions in the conceptual model that will be utilized in the development of RAOs for the North Bronson site. Ecological and NPDES requirements will be addressed in a separate document.

The conceptual model and methodologies for the human health-based RAOs are presented in a general context in Section 2. The presentation provides a general outline and discussion of the planned approach. This approach will be implemented to develop a final RAO report.

2.0 REMEDIAL ACTION OBJECTIVE (RAO) DETERMINATION METHODOLOGY

Site-specific RAOs for the North Bronson site will be determined in accordance with applicable guidance on risk assessment methodology issued by the U.S. EPA, and will utilize current toxicity information and standard MDEQ Industrial default exposure assumptions where appropriate. Consistent with U.S. EPA's *Guidelines for Exposure Assessment* (U.S. EPA, 1992a), conservative but realistic, site-specific assumptions will be used for those exposure parameters where default assumptions do not accurately characterize potential exposures at the site. Environmental Standards currently is in the process of obtaining that information. Appropriate justification for the use of all site-specific exposure assumptions will be included in the RAO Report. The following U.S. EPA guidance documents will be utilized in developing the RAOs for the North Bronson site:

- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual/ Part A (RAGS/Part A)* (U.S. EPA, 1989a);

- *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual/ Part B, Development of Risk-based Preliminary Remediation Goals (RAGS/Part B)* (U.S. EPA, 1991e);

- *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"* (U.S. EPA, 1991a);

- *EPA National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Under The Comprehensive Environmental Response, Compensation And Liability Act of 1980* (U.S. EPA, 1993);

- *CERCLA Compliance with Other Laws Manual* (U.S. EPA, 1988);

- *Exposure Factors Handbook* (U.S. EPA, 1989b);

- *Guidelines for Exposure Assessment* (U.S. EPA 1992a);

- *Dermal Exposure Assessment: Principles and Applications* (U.S. EPA, 1992b);

- *Guidance for Data Usability in Risk Assessment (Part A)* (U.S. EPA, 1992c);

- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (U.S. EPA, 1992d);

- *Guidance on Residential Lead-Based Paint, Lead-Contaminated Dust, and Lead-Contaminated Soil* (U.S. EPA, 1994a);

- EPA Region III *Technical Guidance Manual; Chemical Concentration Data Near the Detection Limit* (U.S. EPA, 1991b);

- EPA Region III *Technical Guidance Manual; Exposure Point Concentrations In Groundwater* (U.S. EPA, 1991c);

- EPA Region III *Technical Guidance Manual; Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening* (U.S. EPA, 1993);

- EPA Region III *Technical Guidance Manual; Use of Monte Carlo Simulation in Risk Assessments* (U.S. EPA, 1994b); and

- EPA Region III Semiannual *Risk-Based Concentration Table* (U.S. EPA, 1995).

Development of RAOs can be considered backward risk calculations. Specifically, the RAO paradigm uses the same parameters as the risk model, but instead of calculating the risk from exposure to a specific concentration of a chemical in a given medium, the RAO model estimates the concentration of a chemical which will elicit a specific risk (or hazard). Consistent with part 201 [20120a(2)], the approach will utilize only reasonable and relevant exposure pathways in the development of site-specific criteria. In addition, RAOs may consider land use or resource use restrictions pursuant to section 20120a(1)(f) to (j) or 20120a(2) and 20120b(4) and (5) of Part 201. For the purpose of this assessment, Environmental Standards will estimate site-specific RAOs that are protective to human health at 1×10^{-5} cancer risk, or a hazard quotient of 1 for noncarcinogens. The four basic phases of a human health risk assessment described in EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual* (RAGS) (U.S. EPA, 1989a) are also required for the development of RAOs. The phases are as follows:

1) <u>Data evaluation</u> - the process of analyzing site data relevant to potential human health impacts;

2) <u>Exposure assessment</u> - the identification of relevant exposure pathways and populations at probable risk, estimation of exposure point concentrations and estimation of average daily intakes;

3) <u>Toxicity assessment</u> - the determination of chemical dose-response relationships and daily intake levels at which no adverse effects or unacceptable cancer risks can reasonably be anticipated to result;

4) <u>Risk characterization</u> - a comparison of estimated daily chemical intake levels with acceptable daily intake levels to generate quantitative expressions of hazard (for noncarcinogens) and the upper limits of probability of causing cancer (for carcinogens).

The specific methodologies to be employed in each of the four stages of the RAO determination are detailed in the following sections.

2.1 Data Evaluation

Chemicals of potential concern will be selected from data for soil, sediment, surface water, and groundwater collected previously as part of the baseline human health risk assessment of the North Bronson site. Environmental Standards assumes for purposes of the RAO assessment that all data collected during the previous investigation has undergone data validation and represents the most current and credible data available for the North Bronson site. Chemicals of potential concern will be selected according to methodologies presented in *RAGS/Part A* (U.S. EPA, 1989a) which describes a "Concentration-Toxicity Screen" whereby constituents can be eliminated from the risk assessment. Specifically, a tiered approach will be used to screen out chemicals and ultimately develop site-specific RAOs. For each of the media on the North Bronson site, goodness-of-fit tests will be applied to the chemical-specific data sets collected previously in order to determine if the individual chemicals are distributed normally or lognormally throughout a specific medium. The Shapiro-Wilk W test (Gilbert, 1987) initially will be applied to the data sets to determine normality or lognormality. Depending upon the confidence or conclusiveness of the result for an individual test, a data set may be subjected to the Chi-Square, Kolmogorov-Smirnov, or Anderson-Darling methods to test for normality or lognormality. Although there is no "best" approach to goodness-of-fit tests, all of the aforementioned tests have individual strengths and weaknesses that are dependent on the structure of the data set being tested. Thorough descriptions of these tests are presented in Daniel (1990) and D'Agostino and Stephens (1986). In the event that none of the tests are definitive for a particular chemical, a normal distribution will be assumed, particularly for chemicals in soil distributed throughout the entire site (such as would be used to estimate trespasser exposure), because of the generally randomized nature of soil exposure.

Based on the outcome of the goodness-of-fit tests, the appropriate 95-percent upper confidence limit (95UCL) of the mean concentrations will be determined for each constituent in accordance with U.S. EPA guidance. The first step in the tiered process will be to compare the 95UCLs to appropriate background data. The 95UCLs for those chemicals which exceed the background levels will be compared with generic industrial soil direct contact criteria and soil-to-

water criteria (i.e., 20 × MCL). GSI criteria will be evaluated in a separate report. In accordance with section 20120a(4) of Part 201, a traditional deterministic approach will be used to estimate site-specific RAOs with a target cancer risk of 1 x 10^{-5} and/or hazard quotient of 1 for those chemicals not eliminated by the aforementioned screening. If the 95UCL for a given chemical and pathway notably exceeds the criteria developed above, then Monte Carlo simulation may be employed as an additional refinement consistent with U.S. EPA (1992a) and section 20120a(14) of Part 201.

2.2   Exposure Assessment

The assumptions and methodologies employed in this analysis will be fully consistent with current EPA guidelines for exposure assessments. The agency has stated its preference for sound scientific information in its *Guidelines for Exposure Assessment* and in the *Proposed Guidelines for Exposure Related Measurements*:

> "The Guidelines do not encourage the use of worst-case assessments, but rather the development of realistic assessments based on the best data available" (Federal Register, Vol. 51, p. 34053, 1986).

In accordance with agency guidelines, standard EPA or MDEQ exposure assumptions will be applied unless more appropriate scientifically defensible values are available. To characterize potential non-cancer effects, comparisons are made between projected average daily intakes of site-related chemicals and toxicity values, Risk Reference Doses (RfDs) or health guidelines developed by EPA. For the characterization of potential carcinogenic effects, concentrations corresponding to 1 × 10^{-5} probability that an individual could develop cancer over a lifetime of exposure are estimated from reasonable maximum exposures and chemical-specific upper-bound slope factors developed by EPA's Carcinogen Assessment Group.'

The objective of an exposure assessment is to estimate the type, magnitude, frequency and duration of exposures to site-related chemicals of potential concern. The procedures for conducting an exposure assessment include the following elements:

- identification of potentially exposed populations and characterization of plausible exposure settings;

- identification of exposure pathways of potential significance; and

- estimation of chemical intakes.

The methodologies employed in the exposure assessment phase of the RAO development will be consistent with EPA's published *Guidelines for Exposure Assessment* (EPA, 1992a), the *Superfund Exposure Assessment Manual* (EPA, 1988), the *Exposure Factors Handbook* (EPA, 1989b) and other related guidance.

2.2.1   Identification of Exposed Populations and Significant Exposure Pathways

All appropriate current and future land use scenarios will be considered in the human health risk assessment. Media of potential concern associated with the North Bronson site include soil, sediment, surface water, and groundwater.

In the exposure assessment phase of RAO development, grounds workers will be considered as a potentially exposed population. The grounds worker is an industrial employee whose responsibilities involve upkeep of the facility. The grounds worker scenario is similar to the traditional commercial/industrial worker scenario, except it is more conservative in that it assumes more direct contact with surface soils through activities like planting, lawn mowing, or raking leaves. The grounds worker may be exposed via inhalation of VOC vapors and fugitive dust in air, as well as through incidental ingestion of, and dermal exposure to, chemicals in surface soil. It should be noted, however, that dermal contact with volatile constituents in soil does not represent a significant route of exposure (Howd and McKone, 1991). For volatile organics, the risk of dermal absorption is not dependent upon dermal permeability, but rather on the rate of evaporative loss from the soil particulates that become airborne prior to deposition on the skin surface, or following the adherence on the skin surface of VOC-contaminated soil contacted directly. Loss of chemicals from soil *in situ* has been measured many times. The equations of Dragun (1988) suggest that the depletion rate is fairly rapid although slower than with some other models. Solvents have much

shorter half-lives on individual particles in air or on skin, because of the short diffusion distances (Howd and McKone, 1991). Howd et al. (1991) estimated that the half-life of volatile organics from soil particles in air is on the order of 0.04 and 0.2 seconds for benzene, for example, at particle sizes of 5 μm and 25 μm, respectively. These same authors estimate the evaporative half-lives of most VOCs from soil particles on skin are about an order of magnitude less (i.e., 4 to 10 milliseconds). Under conservative assumptions of exposure, Howd et al. (1991) estimated that the uptake of carbon tetrachloride, for example, following dermal contact (1000 mg CCl$_4$/kg soil at initial contact) is about 0.04 percent of the initial loading, and uptake of the solvent via ingestion of soil on skin 30 minutes after picking up the VOC-contaminated soil on hands is less than 0.001 percent. Consequently, with regard to direct contact with soil, RAOs for semivolatiles and inorganics will be based on the inhalation, dermal, and ingestion routes, whereas RAOs for VOCs will be determined only with regard to inhalation of vapors. In addition, soil RAOs for the grounds worker (and construction worker) scenario will not be based on soil chemistry data from the entire site, but from each specific area unit.

Based on the results of interviews with children during the performance of the baseline risk assessment it was ascertained that children occasionally trespass onto portions of the site. Consequently, Environmental Standards also considers them to be a potentially exposed population, and will use site-specific exposure factors obtained during the interviews to develop RAOs that would be protective of them. Because of the nature of the children's' activities, they may be exposed to chemicals in sediments in County Drain #30, surface water, and soil. Trespassers/recreational users may be exposed via inhalation of VOC vapors in air, as well as, through incidental ingestion of, and dermal exposure to, chemicals in surface soil, sediment and surface water. Because children frequent different areas of the North Bronson site, RAOs for soil will be based on the distribution of constituents from those areas accessed by children (with the possible exception of CD#30 which may be evaluated separately).

RAOs will also be developed that are protective of workers during construction activities. Inhalation of VOC vapors and fugitive dust will be evaluated for construction workers under this

scenario. In addition, this scenario will consider incidental ingestion of and dermal contact with soil by construction workers for all constituents of potential concern. The same arguments posed for grounds workers also hold for construction workers.

At present no on-site or off-site users of impacted groundwater have been identified. The nature of the affected area and the practicality of institutional controls or restrictive covenants suggests that any risks associated with the future use of ground water could be mitigated by these measures. However, assuming no limitations on the use of off-site groundwater in the future, residential drinking water criteria (as listed in MDEQ's Operational Memorandum #8) or site-specific criteria will be applied at the downgradient property boundary. Fate and transport modeling will be employed to determine RAOs for constituents present in ground water underlying the site and to estimate soil-to-ground water protection criteria. For constituents that have no federal MCLs or promulgated state drinking water standards, acceptable concentrations of ground water constituents at the potential point of use (*i.e.*, downgradient property boundary) may be estimated using standard default factors for ingestion and dermal intake. Inhalation of volatile organic compounds (VOCs) via household use of affected water will be estimated.

Exposure modeling is required to determine the extent of inhalation of volatilized contaminants in the home due to the hypothetical future residential use of off-site ground water. A three-compartment model developed by McKone (1989) is used to simulate the 24-hour concentration profiles of VOCs in the shower, bathroom, and remaining household air volumes as a result of residential water use. This model was developed at Lawrence Berkeley Laboratory and is utilized by CalEPA.

In addition to inhalation of VOCs via household use of water, all constituents in the water supply will be evaluated in terms of dermal absorption while bathing and ingestion of tap water. Calculation of dermal intake while bathing will be determined by utilizing published percutaneous permeability coefficients (*e.g.*, EPA's Dermal Exposure Assessment, 1992). A bathing duration of 0.2 hour and an immersed skin surface equivalent to 90% of the total skin surface area are routinely applied. For ingestion of tap water, an ingestion rate of 2 liters per day, 75% of which is from the

home tap, over a period of 30 years is assumed in accordance with EPA's recommended default values (1989a, 1989b).

2.2.2 Estimation of Chemical Intakes

Chemical intake is expressed as the amount of the agent at the exchange boundaries of an organism (*i.e.*, skin, lungs, gut) which is available for systemic absorption. An applied dose is defined as the amount of a chemical at the absorption barriers such as skin, lung, digestive tract, available for absorption and is (usually measured in milligrams, or mg) absorbed per unit of body weight of the receptor (usually expressed in units of kilogram, or kg). If the exposure occurs over time, the total exposure can be divided by the time period of interest to obtain an average exposure rate (*e.g.*, mg/kg/day). The general equation, as defined by EPA, for estimating a time-weighted average intake is:

$$\text{intake} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

where:

C	=	chemical concentration at the exposure point (*e.g.*, mg/m^3 air)
IR	=	intake rate (*e.g.*, m^3/hr)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight of exposed individual (kg)
AT	=	averaging time (period over which exposure is averaged, usually measured in days)

All intake equations and exposure assumptions for each of the populations and exposure routes to be evaluated in the risk assessment are summarized in Table 1. Further justification for each exposure parameter selected will be provided in the RAO report.

2.3   Toxicity Assessment

Toxicity assessment involves the evaluation of available toxicity information for the constituents of concern and characterization of the relationship between exposure concentration and the incidence of adverse health effects. Toxicity values derived from this dose-response relationship can be used to estimate the potential for the occurrence of adverse effects in individuals exposed to various constituent levels.

Exposure to a chemical does not necessarily result in adverse effects. The relationship between dose and response defines the quantitative indices of toxicity required to evaluate the potential health risks associated with a given level of exposure. If the nature of the dose-response relationship is such that no effects can be demonstrated below a certain level of exposure, a threshold can be defined and an acceptable exposure level derived. Humans are routinely exposed to naturally-occurring nutrients and man-made chemicals at low levels through the typical diet, air and water, with no apparent adverse effects. However, the potential for adverse effects may occur if the exposure level exceeds the threshold in a variably sensitive population; this threshold applies primarily to chemicals which produce noncarcinogenic (systemic) effects, although there is a growing body of scientific evidence which suggests that exposure thresholds may exist for certain carcinogenic constituents as well. (EPA's current approach to assessing carcinogenic risk conservatively assumes that there is no threshold level of exposure, and that any level of exposure to a carcinogen results in some level of potential risk).

Adverse effects can be caused by acute exposure, which is a single or short-term exposure to a toxic substance, or by chronic exposure to lower levels on a continuous or repeated basis over an extended period of time. "Acceptable" acute or chronic levels of exposure are considered to be without any anticipated adverse effects. Such exposure levels are commonly expressed as Reference Doses (RfD), Health Advisories, etc. An acceptable exposure level is calculated to provide an "adequate margin of safety."

Chronic RfDs, which have been derived by EPA for a number of chemicals, are utilized to evaluate exposures lasting 7 to 70 years (EPA, 1989a). Activities involving exposures of shorter duration to chemicals at the North Bronson site are anticipated to result in risk estimates that are much lower than those associated with the long-term exposures, because the concentrations of chemicals found in various media at this site are well below levels that would pose potential concerns with respect to acute (*e.g.*, developmental) or subchronic health hazards.

EPA has derived carcinogenic slope factors for both oral and inhalation pathways, and these are utilized to quantitatively estimate risks. In the first step of EPA's evaluation, the available data are evaluated to determine the likelihood that the agent is a human carcinogen. The evidence is characterized separately for human studies and animal studies as sufficient, limited, inadequate, no data, or evidence of no effect. The characterizations of these two types of data are combined, and based on the extent to which the agent has been shown to be a carcinogen in experimental animals or humans, or both, the agent is given a provisional weight-of-evidence classification. EPA scientists then adjust the provisional classification upward or downward, based on other supporting evidence of carcinogenicity (see Section 7.1.3, *Risk Assessment Guidance for Superfund/Part A*, U.S. EPA 1989a). For a further description of the role of supporting evidence, see the EPA guidelines (EPA, 1986a).

The EPA classification system for weight of evidence is shown in the box in the table below. This system is adapted from the approach taken by the International Agency for Research on Cancer.

EPA WEIGHT-OF-EVIDENCE CLASSIFICATION SYSTEM FOR CARCINOGENICITY	
Group	Description
A	Human carcinogen
B1 or B2	Probable human carcinogen B1 indicates that limited human data are available B2 indicates sufficient evidence in animals and inadequate or no evidence in humans
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

(*RAGS/Part A*, U.S. EPA 1989a)

In several cases, RfD values for oral and inhalation exposures may have not been developed by EPA. In these instances, a thorough search of the literature will be undertaken to determine the best available scientific dose-response toxicity information upon which to derive provisional RfD values. This will be accomplished utilizing well-accepted methodologies adopted by the National Academy of Sciences and endorsed by the EPA.

These procedures and methodologies will be applied to all chemicals of potential concern identified at the North Bronson site in order to determine quantitative expressions of potential risk for every chemical constituent of potential concern. For some of these chemicals, extensive dose-response information from controlled animal studies is available, while for chemicals lacking an EPA-derived RfD or other guideline, very little toxicity information may be available.

Currently, the U.S. EPA has not developed toxicity values to be utilized in dermal exposure scenarios; however, the U.S. EPA does provide the following guidance for dermal exposure:

> "No RfDs or slope factors are available for the dermal route of exposure. In some cases, however, noncarcinogenic or carcinogenic risks associated with dermal exposure can be evaluated using an oral RfD or oral slope factor, respectively. (U.S. EPA, 1989a)."

Therefore, oral toxicity values will be utilized in all dermal exposure pathways considered in the human health risk assessment.

A number of sources of toxicity information exist, and these sources vary with regard to the availability and strength of supporting evidence. The following protocol has been established for the determination of toxicity indices; it defines a hierarchy of sources to be consulted and the methodology for determination of toxicity values. This protocol was developed in accordance with current EPA methodology adopted and/or developed by the National Academy of Sciences. Toxicity values for the chemicals of concern at the North Bronson site will be obtained with reference to the following hierarchy of sources:

1) Toxicity values will be obtained from the *Integrated Risk Information System* (IRIS, EPA, 1991) database. This database contains the Reference Doses (RfDs) and Cancer Slope Factors (CSFs), which have been verified by EPA's RfD and Carcinogen Risk Assessment Verification Endeavor (CRAVE) workgroups, and is, thus, the agency's preferred source for toxicity values. IRIS supersedes all other information sources.

2) For toxicity values which are unavailable on IRIS, the most current source of information is the *Health Effects Assessment Summary Tables* (HEAST, EPA, 1991b), published by EPA. HEAST contains interim, as well as verified, RfDs and CPFs. Supporting toxicity information for verified values is provided in an extensive reference section of HEAST.

3) Toxicity values that cannot be determined in either IRIS or HEAST will be derived from data in toxicological profiles for individual compounds as compiled by the Agency for Toxic Substances and Disease Registry (ATSDR). These documents provide results from a number of toxicological studies, as well as the methodologies and assumptions used in the studies. Toxicological values for a given compound

will be derived from the study summarizing the best available data or the set of data which exhibits either the lowest value for Lowest-Observed-Adverse-Effect-Level (LOAEL) or the highest No-Observed-Adverse-Effect-Level (NOAEL). The LOAEL is the lowest dosage at which some effect is shown. The NOAEL is the dosage at which no observed effect or response is noted. Derivation of the acceptable daily intake will incorporate uncertainty factors for: extrapolation of data from animals to humans, calculation of the human-equivalent dose, and interspecies variability in sensitivity of the toxicant.

4) If a toxicological profile from ATSDR is not available, toxicity data will be obtained in a literature search of EPA sources in the following order:

a) Health Assessment Documents

b) Health Effects Assessments

c) Health Advisories

d) Registry of Toxic Effects of Chemical Substances (RTECS) and Hazardous Substances Data Bank (HSDB).

5) If the above sources cannot provide data, Toxline and other related databases and journals will be searched for relevant dose-response studies upon which to derive toxicity values, using sound principles of toxicology.

6) If the above sources cannot provide data, toxicity values will be derived from Threshold Limit Values (TLVs). Acceptable intake levels can be derived from TLVs by correcting for continuous exposure and dividing by appropriate and conservative safety factors.

7) For chemicals which lack any toxicity information, the concept of structure-activity relationships will be applied. This concept allows the derivation of an acceptable intake for a chemical by inference and analogy to closely related compounds.

2.4 Risk Characterization -- Development of Site-Specific Remedial Action Objectives

In accordance with section 20120a(2) and (4), RAOs will be developed which correspond to an excess lifetime cancer risk of 1×10^{-5} and/or a hazard quotient of 1.0 for each constituent of concern utilizing the site-specific exposure assessment paradigm for the most sensitive receptor.

For example, the most sensitive receptor for direct contact to sediments and water in CD#30 is likely to be adventurous children. For direct contact to surface soils, a grounds worker, for example, may represent the exposure scenario which dictates the most restrictive RAOs. For subsurface soils, the construction worker scenario is likely to determine direct contact cleanup criteria. For each exposure scenario and receptor, intakes from inhalation, dermal absorption and/or ingestion will be summed in the calculations of RAOs which correspond to the target cancer risk of 1×10^{-5} and/or a hazard quotient of 1.0. RAOs for direct contact to soil constituents will then be compared to the 95 UCLs of the mean concentrations to determine whether remedial response activity or land use or resource use restrictions are required pursuant to section 20120b.

In order to determine whether concentrations of constituents in soil that are protective of groundwater are more or less restrictive than the direct contact values, fate and transport modeling will be employed to estimate soil concentrations on site that will meet residential drinking water standards off-site.

Environmental Standards proposes to employ fate and transport modeling to better identify site-specific soil cleanup goals that will be protective of site groundwater. Environmental Standards will use an EPA-developed model (MultiMed, V2.0 or later) to estimate the leaching potential of site-specific COCs. As an optional fate and transport evaluation method, Environmental Standards may wish to consider conducting leachate tests in accordance with MDEQ Operational Memorandum 12. The results of this leachate test can then be compared to health based drinking water values or state drinking water standards. Leaching tests would most likely need to be performed on several different waste types (Eastern and Western Lagoons, for example). While more costly, such testing will provide much higher quality data for model calibration and input.

Once the soil-to-ground water pathway has been modeled and evaluated, modeling chemical fate during ground water transport can be completed. Environmental Standards will conduct this transport modeling using currently available site information, augmented with Geraghty and Miller's understanding of local hydrogeologic conditions. In this way, the

model input assumptions will be consistent with Geraghty and Miller's understanding of ground water flow.

Ground water exposure point concentrations will be estimated through selecting a hypothetical point of use at the compliance boundary (excluding County Drain #30 issues, we currently assume this to be the downgradient property line). Fate and transport modeling of the COCs behavior through time will be assessed to identify short-term and long-term exposure risks at the point of compliance. This process may be completed for several locations along the downgradient property boundaries.

In addition, if it is discovered through modeling that residual COC concentrations in soil will result in a ground water quality exceedence at the point of compliance, a soil concentration estimate could be developed regarding the minimum downgradient distance at which ground water is modeled to be in compliance of ground water quality standards (i.e. how far away from the site is ground water affected at levels exceeding drinking water standards). This calculation can be used as a decision-making tool when developing a strategy which optimizes the potential on-site soil and ground water clean-up approach. In this way, clean-up standards could be developed such that off-site affects are either minimized, or controlled to a level satisfactory to U.S. EPA and MDEQ.

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TABLES

Table 1

Parameters Used in the Quantitative Derivation of Site-specific Remedial Action Objectives for the North Bronson Site

Scenario	Contact Rate	Exposure Frequency and Duration	Absorption	Body Weight	Averaging Time
Ingestion of Soil - Occupational Use (associated with dermal contact) *Construction Workers*	Ingestion Rate: 50 mg/day (1)	125 shifts/year (2) 1 year (2)	Volatiles - 0% (12) Non-vol. - 50% (1)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 1 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Dermal Exposure to Contaminants in Soil - Occupational Use *Construction Worker*	Skin Surface Area Available for exposure: 2570 cm^2 /day (1)	125 shifts/year (2) 1 year (2)	Volatiles - 0.1% (12) Non-volatiles - 1% (1) Adherence: 1 mg/cm^2 (1)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 1 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Inhalation of Vapors during Excavation Activities *Construction Workers*	Inhalation Rates: 20 m3/shift (4)	125 shifts/year (2) 1 year (2)	Alveolar absorp.: 0.5 or 1.0 (5)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 1 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Ingestion of Soil - Occupational Use (associated with dermal contact) *Grounds Workers*	Ingestion Rate: 50 mg/day (1)	112 shifts/year (1)* 21 year (1)	Volatiles - 0% (12) Non-vol. - 50% (1)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 21 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Dermal Exposure to Contaminants in Soil - Occupational Use *Grounds Workers*	Skin Surface Area Available for exposure: 2570 cm^2 /day (1)	112 shifts/year (1)* 21 year (1)	Volatiles - 0.1% (12) Non-volatiles - 1% (1) Adherence: 1 mg/cm^2 (1)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 21 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime

ENVIRONMENTAL STANDARDS

Table 1

Parameters Used in the Quantitative Derivation of Site-specific Remedial Action Objectives for the North Bronson Site

Scenario	Contact Rate	Exposure Frequency and Duration	Absorption	Body Weight	Averaging Time
Inhalation of Vapors during Excavation Activities Grounds Workers	Inhalation Rates: 20 m3/shift (4)	112 shifts/year (1)* 21 year (1)	Alveolar absorp.: 0.5 or 1.0 (5)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 21 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Ingestion of Soil (associated with dermal contact) Children, ages 6-15 years	Ingestion Rate: 100 mg/day (4)	6 days/year (6) 9 years (2)	Volatiles - 0% (12) Non-vol. - 50% (1)	52 kg (7)	For noncarcinogenic effects: Exposure is averaged over 9 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Dermal Exposure to Contaminants in Soil - Recreational Use Children, ages 6-15 years	Fraction surface area available: 31.3% (8) Total surface area: 14,700 cm2 (8)	6 days/year (6) 9 years (2)	Volatiles - 0.1% (12) Non-volatiles - 1% (1) Adherence: 1 mg/cm^2 (1)	52 kg (7)	For noncarcinogenic effects: Exposure is averaged over 9 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Inhalation of Vapors from Soil - Recreational Use Children, ages 6-15 years	Inhalation Rate: 1.5 m3/hour (8)	4 hours/day (2) 6 days/year (6) 9 years (2)	Alveolar absorp.: 0.5 or 1.0 (5)	52 kg (7)	For noncarcinogenic effects: Exposure is averaged over 9 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Ingestion Exposure to Contaminants in Groundwater - Residential Use Off-site Future Adult Resident	Fluid Ingestion Rate: 2 liters/day (3) Intake of home water fraction: 0.75 (8)	350 days/year (9) 30 years (3)	100% absorption (2)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 30 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Dermal Exposure to Contaminants in Groundwater - Residential Use Off-site Future Adult Resident	Fraction surface area available: 90% (2) Total surface area: 20,000 cm2 (8)	0.2 hr/day (3) 350 days/year (9) 30 years (3)	Permeability constant (Kp) m/hr chemical specific (10)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 30 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime

ENVIRONMENTAL STANDARDS

Table 1
Parameters Used in the Quantitative Derivation of Site-specific Remedial Action Objectives for the North Bronson Site

Scenario	Contact Rate	Exposure Frequency and Duration	Absorption	Body Weight	Averaging Time
Inhalation Exposure to Contaminants in Groundwater - Shower Residential Use Off-site Future Adult Resident	Inhalation Rate: 0.625 m3/hr (4)	0.2 hr/day (3) 350 days/year (9) 30 years (3)	100% absorption (4)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 30 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Inhalation Exposure to Contaminants in Groundwater - Bathroom Residential Use Off-site Future Adult Resident	Inhalation Rate: 0.625 m3/hr (4)	0.33 hrs/day (11) 350 days/year (9) 30 years (3)	100% absorption (4)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 30 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime
Inhalation Exposure to Contaminants in Groundwater - Whole House Residential U Off-site Future Adult Resident	Inhalation Rate: 0.625 m3/hr (4)	14 hrs/day (11) 350 days/year (9) 30 years (3)	100% absorption (4)	70 kg (3)	For noncarcinogenic effects: Exposure is averaged over 30 year period; exposure is of chronic duration For carcinogenic effects: Exposure is averaged over a 70-year lifetime

Notes:
*Site-specific valures may be substituted as more site-specific data becomes available
(1) MDNR 1995, Environmental Response Devision Operational Memorandum # 14 Revision 2
(2) Reasonable Maximum
(3) U.S. EPA 1989, Risk Assessment Guidance for Superfund, Part A
(4) U.S. EPA 1991, Human Health Evalulation Manual, Supplemental Guidance
(5) Dependent upon whether toxicity indices were derived on an absorbed or administered dose
(6) Site Specific information - Warzyn Baseline Risk Assessment, 1994
(7) U.S. EPA 1985, Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessment
(8) U.S. EPA 1989, Exposure Factors Handbook
(9) MDNR 1995, Interim Environmental Response Division Operational Memorandum #8, Revision 4
(10)U.S. EPA 1991, Interim Guidance for Dermal Exposure Assessment, Guy and Brounagh permeability estimation
(11) McKone, T.E. and K.T. Bogen 1991, Predicting the Uncertainties in Risk Assessment
(12) See test for justification

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